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DESIGN GUIDANCE FOR RADIOACTIVE WASTE MANAGEMENT SYSTEMS, STRUCTURES, AND COMPONENTS INSTALLED IN LIGHT-WATER-COOLED NUCLEAR POWER PLANTS

A. INTRODUCTION

Paragraph (a) of § 50.34, "Contents of applications; technical information," of 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," requires that each application for a construction permit include a preliminary safety analysis report. Part of the information required is a preliminary design of the facility, including among other things the principal design criteria for the facility. Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50 establishes minimum requirements for the principal design criteria for water-cooled nuclear power plants.

Criterion 1, "Quality Standards and Records," of Appendix A requires that structures, systems, and components important to safety be designed, fabricated, erected, and tested to quality standards commensurate with the importance to safety of the safety function to be performed. Criterion 2, "Design Bases for Protection Against Natural Phenomena," of Appendix A requires, among other things, that structures, systems, and components important to safety be designed to withstand the effects of natural phenomena such as earthquakes without loss of capability to perform their safety functions and that the design bases for these structures, systems, and components reflect the importance of the safety functions to be performed. Criterion 60, "Control of Releases of Radioactive Materials to the Environment," of Appendix A requires that the nuclear power unit design include means to control suitably the release of radioactive materials in gaseous and liquid effluents and to handle radioactive solid waste produced during normal reactor operation, including anticipated operational occurrences.

This guide furnishes design guidance acceptable to the NRC staff relating to seismic and quality group classification and quality assurance provisions for radioactive waste management systems, structures, and components. Further, it describes provisions for controlling releases of liquids containing radioactive materials, e.g., spills or tank overflows, from all plant systems outside reactor containment.

B. DISCUSSION

One aspect of nuclear power plant operation is the control and management of liquid, gaseous, and solid radioactive waste[1] (radwaste) generated as a byproduct of nuclear power. The purpose of this guide is to provide information and criteria that will provide reasonable assurance that components and structures used in the radioactive waste management and steam generator blowdown systems are designed, constructed, installed, and tested on a level commensurate with the need to protect the health and safety of the public and plant operating personnel. It sets forth minimum staff recommendations and is not intended to prohibit the implementation of more rigorous design considerations, codes, standards, or quality assurance measures.

Working Group ANS-55, Radioactive Waste Systems, of Subcommittee ANS-50, Nuclear Power Plant System Engineering, of the American Nuclear Society Standards Committee has developed standards that establish requirements and provide recommendations for the design, construction, and performance of BWR (ANSI N197–1976) and PWR (ANSI N199–1976) liquid radioactive waste processing systems. Standards for gaseous and solid radioactive waste processing systems are being developed.

[1] Radioactive waste, as used in this guide, means those liquids, gases, or solids containing radioactive materials that by design or operating practice will be processed prior to final disposition.

These standards provide more detailed guidance with regard to the specific requirements of the radioactive waste processing system than are presented in this guide. It is expected that these standards will be endorsed separately to be used in conjunction with this guide or that reference to applicable sections may be used in future revisions to this guide.

For the purpose of this guide, the radwaste systems are considered to begin at the interface valve(s) in each line from other systems provided for collecting wastes that may contain radioactive materials and to include related instrumentation and control systems. The radwaste system terminates at the point of controlled discharge to the environment, at the point of recycle back to storage for reuse in the reactor, or at the point of storage of packaged solid wastes prior to shipment offsite to a licensed burial ground. The steam generator blowdown system begins at, but does not include, the outermost containment isolation valve on the blowdown line. It terminates at the point of controlled discharge to the environment, at the point of interface with other liquid systems, or at the point of recycle back to the secondary systems. Except as noted, this guide does not apply to the reactor water cleanup system, the condensate cleanup system, the chemical and volume control system, the reactor coolant and auxiliary building equipment drain tanks, the sumps and floor drains provided for collecting liquid wastes, the boron recovery system, equipment used to prepare solid waste solidification agents, the building ventilation systems (heating, ventilating, and air conditioning), or the chemical fume hood exhaust systems.

The design and construction of radioactive waste management and steam generator blowdown systems should provide assurance that radiation exposures to operating personnel and to the general public are as low as is reasonably achievable. One aspect of this consideration is ensuring that these systems are designed to quality standards that enhance system reliability, operability, and availability. In development of this design guidance, the NRC staff has considered designs and concepts submitted in license applications and resulting operating system histories. It has also been guided by industry practices and the cost of design features, taking into account the potential impact on the health and safety of operating personnel and the general public.

C. REGULATORY POSITION

1. Systems Handling Radioactive Materials in Liquids

1.1 The liquid radwaste treatment system including the steam generator blowdown system downstream of the second containment isolation valve should meet the following criteria:

1.1.1 These systems should be designed and tested to requirements set forth in the codes and standards listed in Table 1 supplemented by the provisions in 1.1.2 and in regulatory position 4 of this guide.

1.1.2 Materials for pressure-retaining components should conform to the requirements of the specifications for materials listed in Section II of the ASME Boiler and Pressure Vessel Code,[2] except that malleable, wrought, or cast iron materials and plastic pipe should not be used. Materials should be compatible with the chemical, physical, and radioactive environment of specific applications. Manufacturers' material certificates of compliance with material specifications, such as those contained in the codes referenced in Table 1, may be provided in lieu of certified material test reports.

1.1.3 Foundations and walls of structures that house the liquid radwaste system should be designed to the seismic criteria described in regulatory position 5 of this guide to a height sufficient to contain the maximum liquid inventory expected to be in the building.

1.1.4 Equipment and components used to collect, process, and store liquid radioactive waste need not be designed to the seismic criteria given in regulatory position 5 of this guide.

1.2 All tanks located outside reactor containment and containing radioactive materials in liquids should be designed to prevent uncontrolled releases of radioactive materials due to spillage (in buildings or from outdoor tanks). The following design features should be included for tanks that may contain radioactive materials:

1.2.1 All tanks inside and outside the plant, including the condensate storage tanks, should have provisions to monitor liquid levels. Potential overflow conditions should actuate alarms both locally and in the control room.

1.2.2 All tank overflows and drains and sample lines should be routed to the liquid radwaste treatment system.[3]

1.2.3 Indoor tanks should have curbs or elevated thresholds with floor drains routed to the liquid radwaste treatment system.[3]

1.2.4 The design should include provisions to prevent leakage from entering unmonitored systems and ductwork in the area.

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[2] Copies may be obtained from the American Society of Mechanical Engineers, United Engineering Center, 345 East 47th Street, New York, New York 10017.

[3] Retention by an intermediate sump or drain tank designed for handling radioactive materials and having provisions for routing to the liquid radwaste system is acceptable.

1.2.5 Outdoor tanks should have a dike or retention pond capable of preventing runoff in the event of a tank overflow and should have provisions for sampling collected liquids and routing them to the liquid radwaste treatment system.

2. Gaseous Radwaste Systems

2.1 The gaseous radwaste treatment system[4] should meet the following criteria:

2.1.1 The systems should be designed and tested to requirements set forth in the codes and standards listed in Table 1 supplemented by the provisions noted in 2.1.2 and in regulatory position 4 of this guide.

2.1.2 Materials for pressure-retaining components should conform to the requirements of the specifications for materials listed in Section II of the ASME Boiler and Pressure Vessel Code[2] except that malleable, wrought, or cast iron materials and plastic pipe should not be used. Materials should be compatible with the chemical, physical, and radioactive environment of specific applications. Manufacturers' material certificates of compliance with material specifications, such as those contained in the codes referenced in Table 1, may be provided in lieu of certified materials test reports.

2.1.3 Those portions of the gaseous radwaste treatment system that are intended to store or delay the release of gaseous radioactive waste, including portions of structures housing these systems, should be designed to the seismic design criteria given in regulatory position 5 of this guide. For the systems that normally operate at pressures above 1.5 atmospheres (absolute), these criteria should apply to isolation valves, equipment, interconnecting piping, and components located between the upstream and downstream valves used to isolate these components from the rest of the system (e.g., waste gas storage tanks in the PWR) and to the building housing this equipment. For systems that operate near ambient pressure and retain gases on charcoal adsorbers, these criteria should apply to the tank support elements (e.g., charcoal delay tanks in a BWR) and the building housing the tanks.

3. Solid Radwaste System

3.1 The solid radwaste system consists of slurry waste collection and settling tanks, spent resin storage tanks, phase separators, and components and subsystems used to solidify radwastes prior to offsite shipment. The solid radwaste handling and treatment system should meet the following criteria:

[4] For a BWR this includes the system provided for treatment of normal offgas releases from the main condenser vacuum system beginning at the point of discharge from the condenser air removal equipment; for a PWR this includes the system provided for the treatment of gases stripped from the primary coolant.

3.1.1 The system should be designed and tested to the requirements set forth in the codes and standards listed in Table 1 supplemented by the provisions noted in 3.1.2 and in regulatory position 4 of this guide.

3.1.2 Materials for pressure-retaining components should conform to the requirements of the specifications for materials listed in Section II of the ASME Boiler and Pressure Vessel Code[2] except that malleable, wrought, or cast iron materials and plastic pipe should not be used. Materials should be compatible with the chemical, physical, and radioactive environment of specific applications. Manufacturers' material certificates of compliance with material specifications, such as those contained in the codes referenced in Table 1, may be provided in lieu of certified materials test reports.

3.1.3 Foundations and adjacent walls of structures that house the solid radwaste system should be designed to the seismic criteria given in regulatory position 5 of this guide to a height sufficient to contain the maximum liquid inventory expected to be in the building.

3.1.4 Equipment and components used to collect, process, or store solid radwastes need not be designed to seismic criteria given in regulatory position 5 of this guide.

4. Additional Design, Construction, and Testing Criteria

In addition to the requirements inherent in the codes and standards listed in Table 1, the following criteria, as a minimum, should be implemented for components and systems considered in this guide:

4.1 The quality assurance provisions described in regulatory position 6 of this guide should be applied.

4.2 Process piping systems include the first root valve on sample and instrument lines. Pressure-retaining components of process systems should use welded construction to the maximum practicable extent. Flanged joints or suitable rapid disconnect fittings should be used only where maintenance or operational requirements clearly indicate that such construction is preferable. Screwed connections in which threads provide the only seal should not be used except for instrumentation connections where welded connections are not suitable. Process lines should not be less than 3/4 inch (nominal I.D.). Screwed connections backed up by seal welding, mechanical joints, or socket welding may be used on lines 3/4 inch or larger but less than 2-1/2 inches (nominal I.D.). For lines 2-1/2 inches and above, pipe welds should be of the butt-joint type. Nonconsumable backing rings should not be used in lines carrying resins or other particulate material. All welding constituting the pressure boundary of pressure-retaining

components should be performed in accordance with ASME Boiler and Pressure Vessel Code Section IX.[2]

4.3 Piping systems should be hydrostatically tested in their entirety except at atmospheric tank connections where no isolation valves exist. Pressure testing should be performed on as large a portion of the in-place systems as practicable. Testing of piping systems should be performed in accordance with applicable ASME or ANSI codes, but in no case at less than 75 psig. The test pressure should be held for a minimum of 30 minutes with no leakage indicated.

4.4 Testing provisions should be incorporated to enable periodic evaluation of the operability and required functional performance of active components of the system.

5. Seismic Design for Radwaste Management Systems and Structures Housing Radwaste Management Systems

5.1 Gaseous Radwaste Management Systems[5]

5.1.1 For the evaluation of the gaseous radwaste system described in regulatory position 2.1.3, a simplified seismic analysis procedure to determine seismic loads may be used. The simplified procedure consists of considering the system as a single-degree-of-freedom system and picking up a seismic response value from applicable floor response spectra, after the fundamental frequency of the system is determined. The floor response spectra should be obtained analytically (regulatory position 5.2) from the application of the Regulatory Guide 1.60 design response spectra normalized to the maximum ground acceleration for the operating basis earthquake (OBE), as established in the application, at the foundation of the building housing the gaseous radwaste system. More detailed guidance can be found in Regulatory Guide 1.122, "Development of Floor Design Response Spectra for Seismic Design of Floor-Supported Equipment or Components."

5.1.2 The allowable stresses to be used for steel system support elements should be those given in "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings," adopted in February 1969.[6] The one-third allowable stress increase provisions for combinations involving earthquake loads, indicated in Section 1.5.6 of the specification, should be included. For design of concrete structures, use of ACI 349-76[7] as endorsed in Regulatory Guide 1.142, "Safety-Related Concrete Structures for Nuclear Power Plants (Other Than Reactor Vessels and Containments)," is acceptable.

5.1.3 The construction and inspection requirements for the support elements should comply with those stipulated in AISC or ACI Codes as appropriate.

5.2 Buildings Housing Radwaste Systems

5.2.1 Input motion at the foundation of the building housing the radwaste systems should be defined. This motion should be defined by normalizing the Regulatory Guide 1.60 spectra to the maximum ground acceleration selected for the plant OBE. A simplified analysis should be performed to determine appropriate seismic loads and floor response spectra pertinent to the location of the system, i.e., an analysis of the building by a several-degrees-of-freedom mathematical model and the use of an approximate method to generate the floor response spectra for radwaste systems and the seismic loads for the buildings. No time history analysis is required.

5.2.2 The simplified method for determining seismic loads for the building consists of (a) calculating the first several modal frequencies and participation factors for the building, (b) determining modal seismic loads using regulatory position 5.2.1 input spectra, and (c) combining modal seismic loads in one of the ways described in Regulatory Guide 1.92, "Combining Modal Responses and Spatial Components in Seismic Response Analysis."

5.2.3 With regard to generation of floor response spectra for radwaste systems, simplified methods that give approximate floor response spectra without need for performing a time history analysis may be used.

5.2.4 The load factors and load combinations to be used for the building should be those given in ACI 349-76[7] as endorsed in Regulatory Guide 1.142. The allowable stresses for steel components should be those given in the AISC Manual. (See regulatory position 5.1.2.)

5.2.5 The construction and inspection requirements for the building elements should comply with those stipulated in the AISC or ACI Code as appropriate.

5.2.6 The foundation media of structures housing the radwaste systems should be selected and designed to prevent liquefaction from the effects of the maximum ground acceleration selected for the plant OBE.

5.3 In lieu of the criteria and procedures defined above, optional shield structures constructed around and supporting the radwaste systems may be erected to protect the radwaste systems from effects of housing structural failure. If this option is adopted, the

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[5] For those systems that require seismic capabilities, as indicated in regulatory position 2.1.3.

[6] Copies may be obtained from the American Institute of Steel Construction, Inc., 101 Park Avenue, New York, New York 10017.

[7] Copies may be obtained from the American Concrete Institute, P.O. Box 19150, Redford Station, Detroit, Michigan 48219.

procedures described in regulatory position 5.2 need only be applied to the shield structures while treating the rest of the housing structures as non-seismic Category I.

6. Quality Assurance for Radwaste Management Systems

Since the impact of these systems on safety is limited, a quality assurance program corresponding to the full extent of Appendix B to 10 CFR Part 50 is not required. However, to ensure that systems will perform their intended function, a quality assurance program sufficient to ensure that all design, construction, and testing provisions are met should be established and documented. The following quality assurance program is acceptable to the NRC staff. It is reprinted by permission of the American Nuclear Society from ANSI N199-1976, "Liquid Radioactive Waste Processing System for Pressurized Water Reactor Plants."[8]

"4.2.3 Quality Control. The design, procurement, fabrication and construction activities shall conform to the quality control provisions of the codes and standards specified herein. In addition, or where not covered by the referenced codes and standards, the following quality control features shall be established.

"4.2.3.1 System Designer and Procurer

"(1) Design and Procurement Document Control—Design and procurement documents shall be independently verified for conformance to the requirements of this standard by individual(s) within the design organization who are not the originators of the document. Changes to these documents shall be verified or controlled to maintain conformance to this standard.

"(2) Control of Purchased Material, Equipment and Services—Measures to ensure that suppliers of material, equipment and construction services are capable of supplying these items to the quality specified in the procurement documents shall be established. This may be done by an evaluation or a survey of the suppliers' products and facilities.

"(3) Instructions shall be provided in procurement documents to control the handling, storage, shipping and preservation of material and equipment to prevent damage, deterioration or reduction of cleanness.

[8] Copies may be obtained from American Nuclear Society, 555 North Kensington Avenue, La Grange Park, Illinois 60525.

"4.2.3.2 System Constructor

"(1) Inspection. In addition to required code inspections a program for inspection of activities affecting quality shall be established and executed by, or for, the organization performing the activity to verify conformance with the documented instructions, procedures, and drawings for accomplishing the activity. This shall include the visual inspection of components prior to installation for conformance with procurement documents and the visual inspection of items and systems following installation, cleanness and passivation (where applied).

"(2) Inspection, Test and Operating Status. Measures should be established to provide for the identification of items which have satisfactorily passed required inspections and tests.

"(3) Identification and Corrective Action for Items of Nonconformance. Measures should be established to identify items of nonconformance with regard to the requirements of the procurement documents or applicable codes and standards and to identify the action taken to correct such items."

In Section 4.2.3.2(3), "items of nonconformance" should be interpreted to include failures, malfunctions, deficiencies, deviations, and defective material and equipment.

Sufficient records should be maintained to furnish evidence that the measures identified above are being implemented. The records should include results of reviews and inspections and should be identifiable and retrievable.

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants regarding the NRC staff's plans for using this regulatory guide.

This guide reflects current NRC staff practice. Therefore, except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein is being and will continue to be used in evaluation of submittals in connection with applications for operating licenses, construction permits, or amendments thereto until this guide is revised as a result of suggestions from the public or additional staff review.

TABLE 1

EQUIPMENT CODES

EQUIPMENT	CODES			
	Design and Fabrication	Materials[1]	Welder Qualification and Procedures	Inspection and Testing
Pressure Vessels	ASME Code Section VIII, Div. 1	ASME Code Section II	ASME Code Section IX	ASME Code Section VIII, Div. 1
Atmospheric Tanks	ASME[3] Section III, Class 3, or API 650, or AWWA D-100[2]	ASME Code[2] Section II	ASME Code Section IX	ASME Code[3] Section III, Class 3, or API 650, or AWWA D-100[2]
0-15 PSIG Tanks	ASME[3] Section III, Class 3, or API 620[2]	ASME Code[2] Section II	ASME Code Section IX	ASME Code[3] Section III, Class 3, or API 620[2]
Heat Exchanger	ASME Code Section VIII, Div. 1 and TEMA	ASME Code Section II	ASME Code Section IX	ASME Code Section VIII, Div. 1
Piping and Valves	ANSI B31.1	ASTM and ASME Code Section II	ASME Code Section IX	ANSI B31.1
Pumps	Manufacturers'[4] Standards	ASME Code Section II or Manufacturers Standard	ASME Code Section IX (as required)	ASME[3] Section III Class 3; or Hydraulic Institute

Notes

[1] Manufacturers' material certificates of compliance with material specifications may be provided in lieu of certified material.

[2] Fiberglass reinforced plastic tanks may be used in accordance with appropriate articles of Section 10, ASME Boiler and Pressure Vessel Code, for applications at ambient temperature.

[3] ASME Code stamp, material traceability, and the quality assurance criteria of Appendix B to 10 CFR Part 50 are not required. Therefore, these components are not classified as ASME Code Class 3.

[4] Manufacturers' standard for the intended service. Hydrotesting should be 1.5 times the design pressure.